CHAPTER 1

Seafood and aquaculture markets

This introductory chapter will provide an overview of seafood and aquaculture markets worldwide, the global supply of major seafood and aquaculture species, the location of major markets, and international trade volumes and partners. The chapter continues with a discussion of characteristics of aquaculture products and the market competition between wild-caught and farmed fish. The chapter concludes by summarizing trends in consumption of seafood and aquaculture products. Practical examples from aquaculture are included throughout.

Global trends in seafood and aquaculture markets

Successful industries must be successful in marketing their products yet marketing is not well understood by many aquaculturists. This book both defines and explains many key marketing concepts and components of theory fundamental to a thorough understanding of marketing that is necessary for aquaculture businesses to successfully develop effective marketing plans and strategies. A market can be defined in a number of ways. It can be a location, such as the Fulton Fish Market in New York City or the Tsukiji Market in Tokyo, Japan, a product such as the jumbo shrimp market, a time such as the Lenten season market in the United States or the European Christmas market, or a level such as the retail or wholesale market.

This chapter will focus mostly on geographic markets but will touch on several other levels of markets. Chapter 3 presents more specific information on fundamental marketing terms and concepts.

A frieze in an Egyptian tomb dated to 2500 B.C. shows the harvest of cultured tilapia (Bardach et al. 1972). While this date places aquaculture as an ancient technology, it is still quite young when compared to terrestrial agriculture. Diamond (1999) shows that domesticated species of both crops and animals were

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Table 1.1 Dates of domestication of various plant and animal crops important in the cultural development of humans.

Area	Domesticated		Earliest attested date of domestication
	Plants	Animals	
Independent origins of domestication			
Southwest Asia	Wheat, pea, olive	Sheep, goat	8500 B.C.
China	Rice, millet	Pig, silkworm	By 7500 B.C.
Mesoamerica	Corn, beans, squash	Turkey	By 3500 B.C.
Andes and Amazonia	Potato, manioc	Llama, guinea pig	By 3500 B.C.
Eastern U.S.	Sunflower, goosefoot	None	2500 B.C.
Sahel	Sorghum, African rice	Guinea fowl	By 5000 B.C.
Tropical West Africa	African yams, oil palm	None	By 3000 B.C.
Ethiopia	Coffee, tea	None	Unknown
New Guinea	Sugar cane, banana	None	7000 B.C.
Local demonstration following arrival of founder crops from elsewhere			
Western Europe	Poppy, oat	None	6000–3500 B.C.
Indus Valley	Sesame, eggplant	Humped cattle	7000 B.C.
Egypt	Sycamore fig, chufa	Donkey, cat	6000 B.C.

Source: Diamond (1999).

being cultivated by 8500 B.C. (Table 1.1). Southwest Asia and China served as the birthplace for many types of terrestrial agriculture and aquatic crops. Diamond theorized that areas with sparse game would provide greater returns to the effort in developing farming technologies. For most species of fish, scarcities due to overfishing have become evident only in the latter part of the 1900s. Thus, strong incentives to explore and invest in widespread domesticated production of aquatic plants and animals have been of comparatively recent origin. The ensuing level of scientific and technological development of aquaculture in the 1900s has resulted in a dramatic blossoming of aquaculture industries.

Continued growth in the global economy and in the world's population has resulted in increasing demand for seafood. However, the volume of seafood supplied from capture fisheries across the world has leveled off since about 1994, while the quantity of aquaculture production supplied worldwide has continued to increase (Fig. 1.1). The global supply from capture fisheries increased most rapidly during the late 1950s through the end of the 1960s. From that point, capture fisheries continued to increase, but at a slower rate, reaching slightly more than 95 million metric tons in 1996. Since then, world capture fisheries have fluctuated from 86.8 million to 94.8 million metric tons, averaging about 92 million metric tons. It is clear that most of the increase in the world supply of fish and seafood has been due to the expansion of aquaculture production.

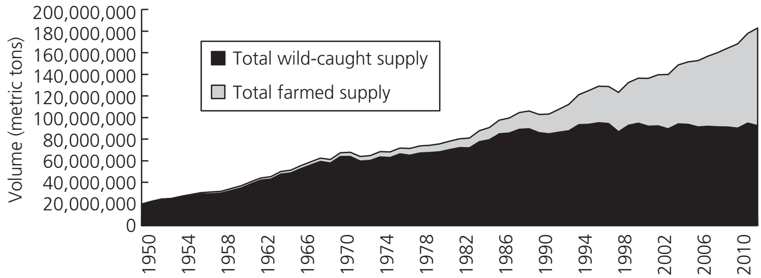

Fig. 1.1 Volume of wild-caught and farmed supply of seafood, 1950–2012. Source: FAO (2014).

Global aquaculture production has increased more than 40-fold, from 2 million metric tons in 1960 to 90.4 million metric tons in 2012 (FAO 2014), while chicken meat production increased by a factor of 10 and beef production doubled (Thornton 2010). From 2008 to 2012, the annual growth rate of cultured finfish and shellfish production averaged 4%. Capture fisheries production has declined by 3% from 1996 to 2012.

All aquatic farming combined represented a 3% share of the world harvest of fish, shellfish, and seaweeds in 1950 (FAO 2014). By 2012, this share had increased to 49.4% and consisted of a record 90.4 million metric tons of total farmed aquatic production. Of this, the greatest increase was for freshwater diadromous fishes (41.97 million metric tons), aquatic plants (23.78 million metric tons), and mollusks (15.17 million metric tons). The total value of aquaculture production worldwide increased to $144.3 billion in 2012.

The relative costs of capture fisheries have increased over time while those of aquaculture production have decreased. In the United States, the Magnuson Fishery Conservation and Management Act established a 200 nautical mile (370 km) Exclusive Economic Zone (EEZ) for commercial fisheries. The U.S. Magnuson Act, combined with declining abundance of many types of fish stocks, requires trawlers to travel greater distances to find supplies of fish. In other parts of the world, countries such as Chile, Ecuador, and Peru have also claimed rights to 200 nautical mile zones for fishing. However, a few countries, such as Papua New Guinea and Anguilla, still use a 5-km limit, while others have moved to a 12 nautical mile limit. Costs of capture fisheries are likely to continue to increase over time. At the same time, aquaculture costs have declined as new technologies have been developed and refined. According to a 2013 World Bank study (World Bank 2013; Kobayashi et al. 2015), global fish supply is projected to rise to 187 million metric tons by 2030. Capture production is expected to remain fairly stable over the 2000–2030 period, with a projected supply of about 93.2 million metric tons in 2030. In contrast, global aquaculture projection is likely to maintain its steady rise, reaching 93.6 million metric tons by 2030. In terms of food fish production, the World Bank study predicts that aquaculture will contribute 62% of the global supply by 2030.

Where are most aquaculture crops produced?

Asia is the birthplace of early aquaculture production technology and continues to be the world's leading aquaculture region. Production in Asia reached 46.7 million metric tons in 2012, accounting for 91% of the world's output (Fig. 1.2). Next to Asia, the Americas was the second leading aquaculture producing region, but with only 4% of total world production. Europe followed closely at 3% of total world production, and Africa at 2%.

The nation that leads the world in aquaculture production is China (Fig. 1.3). Of the top 10 countries in aquaculture production, eight are located in Asia (China, Indonesia, India, Vietnam, The Philippines, Bangladesh, Republic of Korea, and Thailand). Norway and Chile are the only non-Asian countries in the top 10 (ranking eighth and tenth, respectively, in terms of quantity produced). While aquaculture's contribution to world aquatic production averaged 35% in 2002, it reached 66% to 77% in some of the top aquaculture producing countries (China, India).

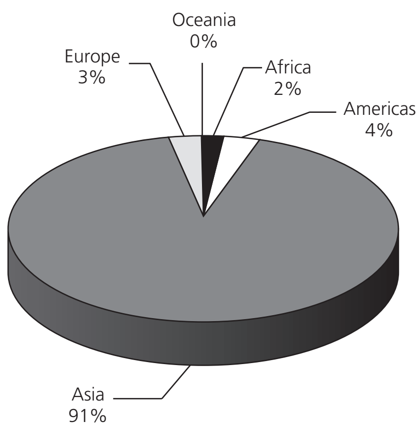

Fig. 1.2 World aquaculture production by region, 2012. Source: FAO (2014).

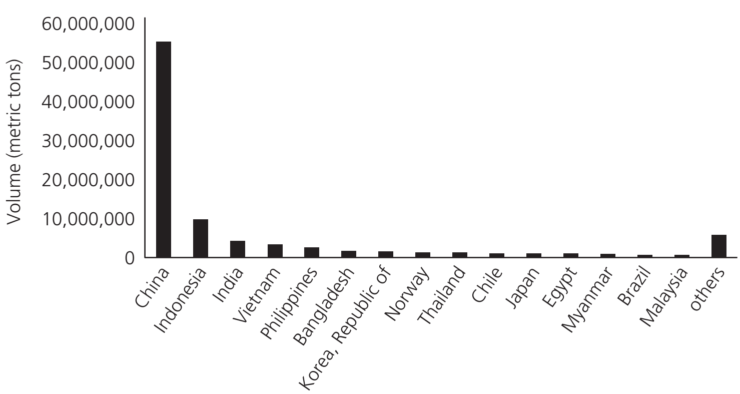

Fig. 1.3 Volume of global aquaculture production by country, 2012. Source: FAO (2014).

Much of the aquaculture production in the world occurs in lesser-developed nations (FAO 2014). Of the top 20 aquaculture producing nations, only three, Japan, Norway, and the U.S., are considered developed nations by the FAO. Moreover, much of the increase in aquaculture production has been from low-income food deficit countries, such as China.

Global aquaculture production has grown at an annual rate of approximately 10% (FAO 2014). Aquaculture production in China grew at an annual rate of about 5%, down from 14% in previous decades. However, the rate of growth of aquaculture in Indonesia was 21% annually from 2000 to 2012, and 17% in Vietnam. By comparison, Africa had the greatest annual percentage increases in production at 12% per year for 2001 to 2012. The Americas and Asia averaged 7%, Europe 3%, and Oceania 4% per year over this same time period.

Global fish production will further concentrate in Asia toward 2030 (World Bank 2013). China is expected to account for an overwhelming 37% of the world's fish production by 2030. Fish supply from other Asian countries/regions (including India and Southeast Asia) will also likely expand. Latin America and Caribbean countries are projected to experience large aquaculture growth over the next 20 years or so (World Bank 2013; Kobayashi et al. 2015).

What are the major species cultured worldwide?

Worldwide, the greatest volume produced of an aquaculture product in 2001 was that of Eucheuma seaweeds (*Eucheuma* spp.), followed by Japanese kelp (*Undaria* spp.), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypophthalmichthys molitrix*), various cupped oysters (*Crassostrea* spp.), common carp (*Cyprinus carpio*), Japanese carpet shell (*Ruditapes philippinarum*), Nile tilapia (*Oreochromis tilapia*), whitelegged shrimp (*Litopenaeus vannamei*), bighead carp (*Hypophthalmichthys nobilis*), various aquatic plants, catla (*Catla catla*), Crucian carp (*Carassius carassius*), wakame (*Undaria pinnatifida*), and Elkhorn sea moss (*Kappaphycus alvarezii*) (Fig. 1.4). The various carp species combined represent the major volume of finfish harvested, by several orders of magnitude. The top three finfish species harvested, by volume, are all different species of carp, and carp are the only finfish other than tilapia included in the list of the top 10 aquaculture products (by volume).

The aquaculture species that generated the greatest value in 2012 was the whitelegged shrimp, followed by Atlantic salmon, grass carp, silver carp, and catla (Fig. 1.5). These top five species in terms of value were followed in descending order by Nile tilapia, common carp, Chinese mitten crab, giant tiger prawn, bighead carp, rainbow trout, Japanese carpet shell, roho labeo, red swamp crawfish, and Crucian carp. Of the top 15, six were carp. However, the overall rankings of the top five valued species have changed dramatically over time. Whitelegged shrimp was not in the top 15 in 2002 but accounted for the highest value in 2012. Atlantic salmon increased from fourth place to second and Nile

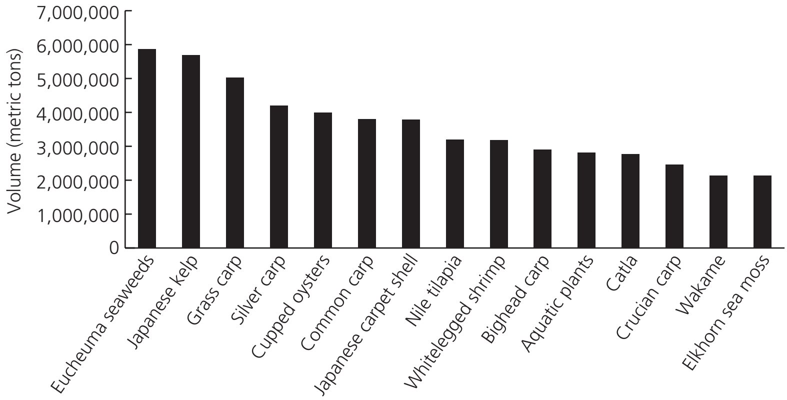

Fig. 1.4 Global aquaculture production of the top 15 species (2012). Source: FAO (2014). nei, not elsewhere indicated.

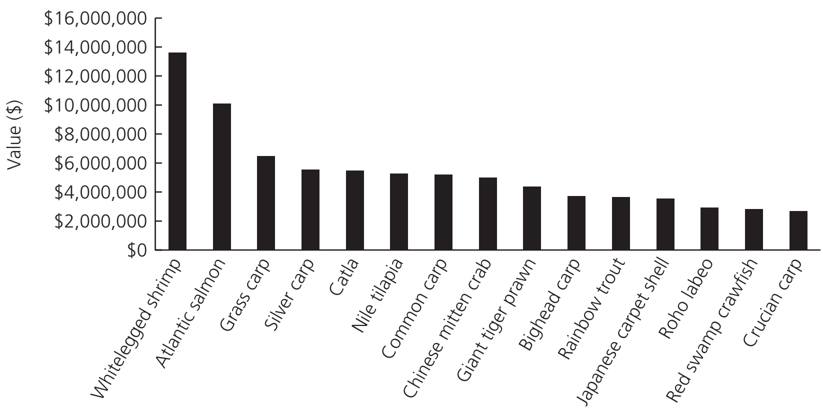

Fig. 1.5 Value of the top 15 farmed species, 2012. Source: FAO (2014).

tilapia increased to the sixth highest value from fifteenth in 2002. Shrimp, salmon, and tilapia combined composed 45% of the total value of aquaculture supplied.

Over the next 20 years or so, further growth in supply is expected for tilapia, carp, and *Pangasius* (World Bank 2013; Kobayashi et al. 2015). Production of some high-value species (such as shrimp and salmon) is also likely to grow over the period. However, only marginal growth in supply is expected for species with limited aquaculture potential.

Real prices of all fish aquaculture species are projected to increase modestly by about 10% during the 2010–30 period (World Bank 2013). However, the real prices of fishmeal, fish oil, and capture fisheries products that are used for these ingredients are expected to rise substantially more than those of fish for direct consumption.

What are the major finfish species caught and supplied to world markets?

The Peruvian anchovy constitutes the greatest volume of worldwide capture fisheries (Fig. 1.6). The primary use of anchovies is for fishmeal production, not as a food product. The second greatest catch is that of pollock. Pollock is used commonly in fish sandwiches, fish sticks, and other popular frozen and breaded preparations. It is also used for production of surimi in many countries. Following pollock are several other types of tuna, herring, and mackerel. Croakers and drums occupied fifteenth place in 2012.

If the volumes of worldwide aquaculture production (Fig. 1.4) are compared with those of worldwide capture fisheries, it is clear that more grass or silver carp are produced worldwide than any single marine species used for direct food consumption by humans[1]. There was also more common carp produced from aquaculture (3.8 million metric tons) than of the next largest volume of wild-caught foodfish, pollock (3.27 million metric tons).

While aquaculture production is approximately equal to that of capture fisheries, culture techniques have been developed for only a limited number of finfish species. In contrast, a large number of different freshwater and marine species are caught and sold, many for production of fishmeal and not for direct human consumption. Thus, there is a great deal of potential for future growth of aquaculture as new culture techniques are developed for other species.

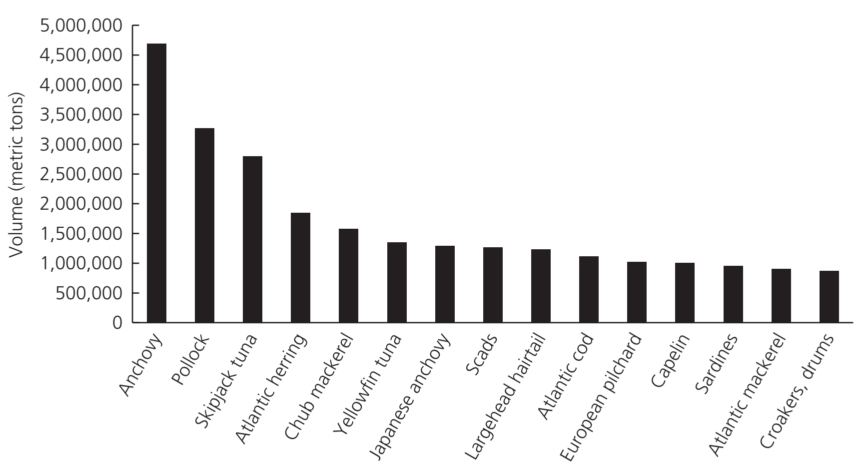

Fig. 1.6 Volume of the top 15 capture species, 2012. Source: FAO (2014).

[1] Grass carp volume was 3.6 million metric tons in 2001 and the volume of Alaskan pollock was 3.1 million metric tons.

What countries are the major markets for seafood and aquaculture?

Per capita consumption of seafood by world region[2] averaged 12–48 kg/capita (Table 1.2) (FAO 2014). However, per capita consumption varied tremendously, even from 0.3 to more than 140 kg/capita within the same region of the world. For example, in the North American region, Greenland averaged per capita seafood consumption of 84.1 kg, while seafood consumption in the U.S. was 22.7 kg/capita. Oceania ranked second, followed by the Far East, and then the Caribbean. Table 1.3 presents the top five countries in terms of highest per capita consumption of seafood for 2001. The country with the highest per capita consumption of fish and seafood in the world, the Maldives, is located in the Far East world region. However, this same region includes countries such as Mongolia (0.1 kg/capita) and Nepal (1.0 kg/capita). In terms of the percentage of countries within a region that consumed more than 25 kg/capita, there were 46% of the countries in the Far East region, 65% in Oceania, and 22% in Europe.

Table 1.3 presents the top five countries in terms of total volume of consumption of fish and seafood in 2007–2009 (NOAA-NMFS 2011). The total amount is clearly related to the combination of per capita consumption and total population. Topping the list was China that has both a high per capita consumption rate and the highest population in the world, resulting in consumption of over 40 million metric tons. Japan followed, with total consumption of 7.2 million metric tons with the U.S. third with 7.1 million metric tons. While per capita consumption in India is among the lowest in the world, it still ranks fourth in total consumption

Table 1.2 Average per capita consumption of fish and shellfish by world region, 2007–09.

Region	Mean ± SD	Maximum	Minimum
		kg/capita	
Africa	13 ± 14	68	0.2
Caribbean	27 ± 14	55	0.57
Europe	20 ± 20	90	0.3
Far East	35 ± 29	141	0.3
Latin America	12 ± 9	35	1.4
Near East	12 ± 9	29	0.0
North America	48 ± 30	86	22.7
Oceania	37 ± 17	74	2.5

Source: NOAA-NMFS (2011).

[2] FAO defines world regions as Africa, the Caribbean, Europe, the Far East, Latin America, the Near East, North America, and Oceania.

Table 1.3 Top five countries worldwide with highest per capita consumption and highest total consumption of fish and seafood, 2007–09.

Country	Per capita consumption (kg/capita)	Total population (million people)	Total consumption of fishery products (metric tons)
Highest per capita consumption			
Maldives	140.8	317,280	44,673
Iceland	89.8	326,340	29,305
Faroe Islands	87.7	48,359	4,241
Greenland	86.1	56,483	4,863
Kiribati	73.8	106,461	7,857
Countries with highest consumption of fish and seafood			
China	30.5	1,365,500,000	41,647,750
Japan	55.9	127,090,000	7,104,331
U.S.	22.7	318,360,000	7,226,772
India	5.5	1,246,460,000	6,855,530
Indonesia	24.7	252,164,800	6,228,471

Source: NOAA-NMFS (2011).

due to its large population. Indonesia completed the top five countries in total consumption of fish and seafood in 2012.

Trade in seafood and aquaculture

Approximately 38% (live weight equivalent) of world fish production was traded internationally in 2010 (FAO 2014). The continued increase in aquaculture production results in continued increases in the total supply of fishery products worldwide.

Are aquaculture products different from agriculture products?

Characteristics of aquaculture products

Aquaculture is a unique form of food production. Most cultured species of fish are not substantially different from wild-caught species. While common carp, with 2000 years of culture, has been bred selectively into strains of fish recognizably different from wild-caught fish, this is not the case for most other cultured aquatic species. Genetic advances may change this situation rapidly, but unlike animal and row crop agriculture, aquaculture growers find themselves competing in the marketplace with wild-caught seafood products. In many cases, wild-caught product still dominates the market and has a major effect on price. Some segments of the aquaculture industry have been more successful than others in differentiating their product from wild-caught supplies.

Aquaculture products offer distinct advantages in terms of control over the product. Many aquaculture products can be supplied year-round. In contrast, most wild-caught seafood is characterized by seasonal fluctuations related to weather and fishing regulations that can result in dramatic price swings. The domination of seafood markets by wild-caught species has resulted in a tendency towards high volatility. While aquaculture products offer the advantage of controlled year-round supply, these products must compete within the volatile seafood market.

Controlled production techniques also allow the aquaculture grower to produce a consistent product. Consistency in supply refers to size, quality, and other product characteristics in addition to consistency in the quantity supplied. Consistently supplied aquaculture products would be expected to lend some stability to the seafood market as the market share of aquaculture products continues to grow over time. Enhanced reliability and regularity in supply of farmed product should enable producers to negotiate better prices (Asche 2001). Theoretically, buyers would be willing to pay higher prices to compensate for reduction in the financial risk that results from supply problems. Market sectors, such as the retail sector, that prefer fresh product, might be expected to prefer farmed supplies (Young et al. 1993). Fresh product requires a short re-order period. Supply chains of captured fisheries products are more fixed due to seasonality of supply and cannot respond readily to changes in retail demand.

Consumers in many countries and for many years have exhibited strong preferences for the freshness of seafood. By contrast, one rarely hears an emphasis on the freshness of beef, pork, or chicken. This strong consumer preference for fresh seafood likely derives from the perishability of seafood as compared to other products. Technological advances enable processors to produce quality frozen and preserved seafood products. However, the preferences for fresh seafood have driven some retail grocers to purchase frozen product, thaw it, and sell it as fresh.

It is easier to trace farmed product back to its original source than wild-caught product. The complexity of market channels for wild-caught product may obscure steps in the supply chain and make tracing products to their source difficult (Asche 2001). Some wild-caught seafood is marked, logged, and stored separately, but this is the exception. The greater traceability of aquaculture products should become increasingly advantageous especially in the U.S. with its country-of-origin labeling laws that require certification of product origin. Individual states in the U.S. also have enacted state laws related to notification of the origin of the seafood sold. Aquaculture suppliers should find compliance less onerous than suppliers of wild-caught seafood.

The potential to control attributes and their levels in a product can offer an opportunity for farmers to target specific consumer segments (Asche 2001).

For example, producing the exact fat content to produce a particular smoked flavor or production of fish of a given size may provide aquaculture growers a significant marketing advantage over capture fisheries. In most cases, additional research will be required to develop cost-effective means of producing these attributes.

Fish and other aquaculture production allows for reliable delivery schedules to comply with contractual agreements to supply fish of a given size and quality grade. The uncertainty of what species, size, and, to some extent, quality of fish will be caught is an important characteristic that can be used to differentiate farm-raised from wild-caught seafood.

The management required for successful aquaculture businesses can be used to reassure consumers of the safety of the product. Consumers increasingly desire assurances that products are free of chemicals, pesticides, and other undesirable additives. This concern can include assurance that the product has not been modified genetically.

A survey of consumers in 2007 showed increasing concerns in the U.S. over food safety (Brewer and Rojas 2008). Greatest concerns were expressed about pesticide residues and hormones in poultry and meat. These concerns have been extended to seafood. The particular concerns for seafood are related to concentrations of dioxin and mercury in seafood products and the status of menhaden and other pelagics used for fishmeal in fish diets (Millar 2001), and levels of metal ions such as mercury in seafood (Petroczi and Naughton 2009).

There has been growing resistance to aquaculture products by some activist groups. There are groups who consider aquaculture as unnatural and detrimental to the environment. In some areas of the U.S., for example, farmed salmon is considered less desirable than wild-caught salmon. On the other hand, some consumers may be convinced to pay a premium price for environmentally sustainable products. Farm-raised catfish is preferred to wild-caught catfish in southern states for a variety of reasons, but primarily for the consistency of flavor, quality, and the certainty that it is free of contaminants and adulterations. U.S. farm-raised tilapia, catfish, trout, and hybrid striped bass are listed as environmentally acceptable seafood choices by the Monterey Bay Aquarium (Seafood Watch 2014).

A major disadvantage of aquaculture products as compared to wild-caught seafood is the price. Costs of production have frequently been higher for aquaculture products than for wild-caught seafood. However, as wild fish stocks have declined and boats have had to travel farther on fewer fishing days, costs of capture fisheries have increased. At the same time, research and development have reduced costs of producing a number of aquaculture species. Thus, there is a greater number of farmed species for which production costs are competitive with those of wild-caught species than before. However, the consistent production and supply of aquaculture products results in more consistent costs and prices. Buyers who are accustomed to waiting for periods of abundant supply and low prices of wild-caught seafood may be reluctant to pay a consistently higher price for aquaculture products.

Market opportunities have developed for aquaculture species when declining stocks of similar wild-caught species resulted in higher prices. This has been the case for hybrid striped bass in the U.S., cultured turbot, halibut, and other species even though framed turbot and halibut are considered inferior to wild-caught product (Asche 2001).

Market competition between wild-caught and farmed finfish

Prices for several aquacultured species such as Atlantic salmon, rainbow trout, sea bass, and sea bream have fallen as production has increased. These finfish species have grown in importance in seafood markets in the European Union and in the U.S. (Asche 2001). Atlantic salmon, rainbow trout, sea bass, and sea bream were high-value species before aquaculture production became significant. The increased supplies from aquaculture have been accompanied by lower prices.

A farmed product that competes in a large market will face limited price effects from increased aquaculture production. As long as supplies of the farmed species are low in comparison with wild-caught species, the impact of the farmed quantity supplied on price will be small.

When the supply of the farmed species is high, farm-level production is likely to determine market price because of the greater control that farmers have over the production process (Asche 2001). Salmon (Asche et al. 1999), catfish (Quagrainie and Engle 2002), tilapia, carp, shrimp, oysters, and mussels are examples of seafood markets that are dominated by farmed production. With few or no substitutes, it may be more difficult for the industry to grow because farmers will then have to create and promote the market for their product.

U.S. catfish was a low-value species prior to development of the catfish farming industry. While price in recent years has been low, there is no clear long-term trend. From 1993 to 2000, the U.S. catfish industry successfully moved its product into new markets, sustaining price ($0.748 ± 0.03/lb) even with consistent growth (4% increase per year from 1993 to 2000) in volumes produced and sold. New market development was predicated upon changing consumer attitudes towards what had been regarded as an inferior, scavenging fish.

Most seafood demand studies show that the seafood market is highly segmented. Farmed species seem to compete mainly with similar, wild species, but not with other species (Asche 2001). However, Dey et al. (2014) showed that, at the retail level in the U.S., there is substitution among species, but the substitutability varied by region, product form, and ethnicity of buyers. Aquaculture growers are capturing market share even though demand studies have not determined clearly what market is being captured. Aquaculture products may create new market segments and may win parts of market shares from a variety of goods such that the effects on individual goods are not measurable (Asche 2001).

Consumption trends in seafood and aquaculture markets, expenditures, effects of income, and at-home versus away-from-home purchases

Until the development of advanced transportation and refrigeration and freezing technologies, the only seafood available was what could be caught locally. There remains a strong tendency for consumers to prefer species that live in nearby water. Many people are conservative and traditional about the fish and seafood that they eat. Consumer preferences typically are based on what they, their family, and their friends have been able to catch or gather from their hometown areas. For example, Engle et al. (1990) asked consumers nationwide what their most preferred type of finfish was. The preferred finfish on the Pacific Coast of the U.S. was salmon. Consumers in the Mountain region preferred trout that is caught in the mountain streams in the region. Catfish was most preferred in the West South Central and East South Central regions where catfish are abundant in the Mississippi River and its tributaries in the south. Catfish was also most preferred by consumers in the West North Central region through which the Mississippi River flows but also has a large number of inhabitants who have moved there from the south. The East North Central region has a tradition of Friday night fish fries that are based on the catch of locally available yellow perch. The Middle and South Atlantic regions have provided consumers with an abundant flounder fishery, and the 1989 survey showed preferences by Middle and South Atlantic consumers for flounder. Haddock was most preferred by consumers in the New England region.

European research showed that fish were associated with the natural environment in which they were found (i.e., the sea, rivers, lagoons, and ponds), leading to regional preferences for fish in Europe as in the U.S. (Gabriel 1990). Kinnucan et al. (1993) supported this by showing that preferences for fish products were influenced to a large degree by source availability.

Preparation methods also vary by region and the associated culinary traditions. Northern Europeans, for example, prefer fish fried, in breadcrumbs, soused, smoked, or cooked in foil (Gabriel 1990). In central Europe, French cuisine dominates and fish are steamed, poached, fried, smoked, simmered, or wrapped in foil. In southern Europe, fish is most often fried, grilled, simmered, or eaten dried.

Consumer tastes and preferences change over time. In the U.S., for example, beef consumption has declined while consumption of poultry has increased. Increasing health concerns and choices of lower-fat protein sources have been credited with the increased consumption of poultry products. However, declines in the cost of producing chicken in the U.S. and the resulting lower prices of chicken as compared to beef, no doubt have contributed to increased consumption of chicken. Pork and seafood consumption patterns, on the other hand, have changed little. Quality and flavor perceptions often have the greatest impact on preferences (Kinnucan et al. 1993). Other variables such as price, household size, coupon value, household income, geographic region, urbanization, race, and seasonality have been shown to explain the variation in household expenditures on fresh and frozen seafood commodities (Cheng and Capps 1988).

Dey et al. (2014), used retail-level scanner data in the U.S. to examine market trends in seafood sales across 52 cities. Frozen seafood sales in supermarkets were found to increase by 6% per year from 2005 to 2010. Retail prices and volume of sales varied considerably by product form, ethnic characteristics of market area, and geographic region. Patterns of substitute and complementary seafood products also varied by region. Thus, it has become more important in recent years to design differentiated marketing strategies that target specific segments of targeted market regions.

Older consumers tend to eat more seafood, particularly if the consumer is health conscious and views seafood as a convenient choice (Olsen 2003). In Belgium, fish was consumed more frequently by women and consumption frequency increased with age (Verbeke and Vackier 2005). However, regional differences were also identified.

The most promising customers for at-home sales were shown to be older, well-educated (four or more years of college), higher-income (more than $30,000), non-white urban-suburban residents in families without young children (age 10 or under) present (Rauniyar et al. 1997). New England households were significantly more likely to be frequent purchasers for at-home use as compared to households in the West North Central and West South Central regions.

Frequent purchasers at restaurants were more likely to have annual incomes above $20,000, and especially above $40,000 (Hanson et al. 1994). The role of income, race, seasonality, few small children and adherence to the catholic faith were found important to restaurant consumption. The recognition in all consumer profiles of fish as a nutritious and healthful product represented an advantage for future marketing strategies in aquaculture.

Aquaculture market synopsis: tilapia

Tilapia (*Oreochromis* spp.; *Tilapia* spp.) is the eighth most important aquaculture crop worldwide in terms of volume (Fig. 1.4) and sixth in terms of value (Fig. 1.5). It is the fourth most important in terms of volume of all finfish and fifth most important in terms of value. World tilapia production has climbed steadily over the last half a century, with a marked increase in the rate of growth beginning in the 1990s (Fig. 1.7). Total worldwide production of tilapia and cichlids exceeded 4.5 million metric tons in 2012. Average annual growth in tilapia production averaged 12.3% from the 1990s to 2012.

There has been a major shift in the countries leading the supply of tilapia over the years. In 1971, for example, the five leading tilapia producing countries

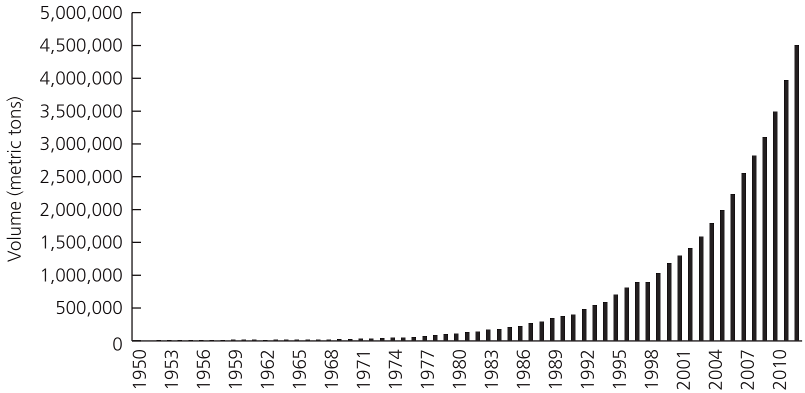

Fig. 1.7 Global tilapia and cichlid production, 1950–2012. Source: FAO (2014).

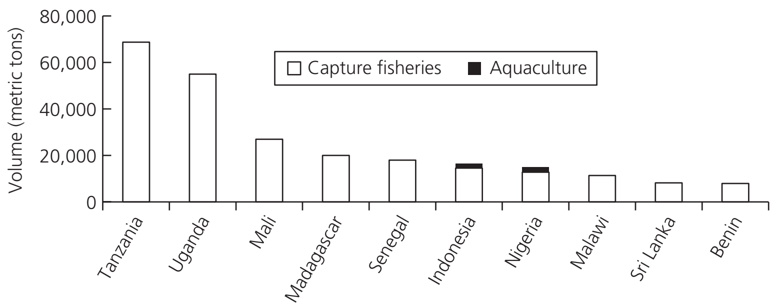

Fig. 1.8 Top ten tilapia producing (capture fisheries and aquaculture) countries, 1971. Source: FAO (2014).

(Tanzania, Uganda, Mali, Madagascar, and Senegal) were all African countries with endemic tilapia populations (Fig. 1.8). All of this supply was from capture fisheries. Only Indonesia and Nigeria registered measurable amounts of tilapia production from aquaculture and these were negligible. By 2012, only one of the five leading tilapia producing countries (China, Egypt, Indonesia, Brazil, and The Philippines) was an African country (Fig. 1.9). Of these countries, only Egypt and Indonesia have endemic populations of tilapia whereas tilapia were introduced into the other countries. Moreover, the supply of tilapia had shifted heavily to production from aquaculture.

China emerged as the dominant world producer of tilapia in the late 1990s. Over the 19-year period from 1994 to 2012, tilapia production increased by 558% with an average annual increase of 29%/yr (Fig. 1.10). Some of this production is exported while other portions of the production are consumed in the domestic market.

The major species of tilapia farmed worldwide is the Nile tilapia (*Oreochromis niloticus*), with 71% of total world production in 2012 (Fig. 1.11). Other, unspecified tilapia composed 20% of global production. The blue tilapia (*Oreochromis*

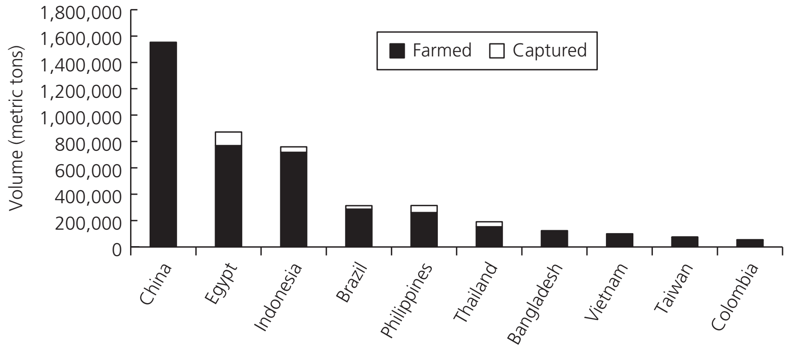

Fig. 1.9 Top ten tilapia producing (farmed and capture) countries, 2012. Source: FAO (2014).

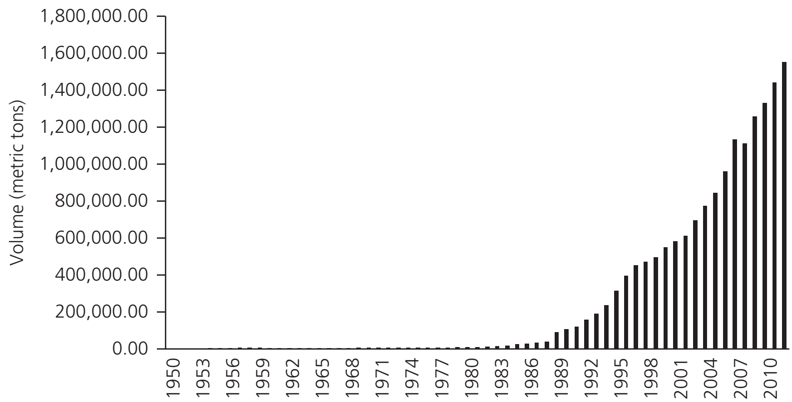

Fig. 1.10 Tilapia production in China, 1950–2012. Source: FAO (2014).

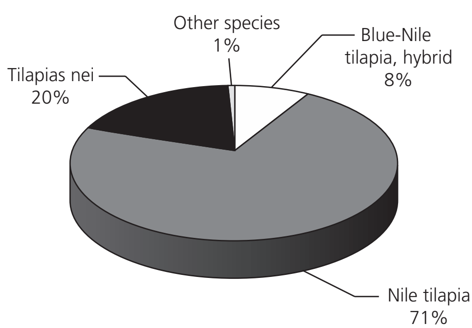

Fig. 1.11 Major species of farmed tilapia worldwide, 2012. Source: FAO (2014).

aureus) – Nile tilapia hybrid accounted for 8% of global production, and a variety of other species composed 1% of world production.

Much of the growth in tilapia aquaculture is a result of the development of improved production practices and both domestic and export market development (Engle 2006). Key technological developments in reproductive control led to rapid growth of commercial-scale aquaculture production (Kumar 2015). Sex reversal technology (Phelps and Popma 2000) was eventually replaced by development of genetically male tilapias through selective breeding (Mair et al. 1997). The GIFT (Genetically Improved Farm Tilapia) program of the WorldFish Center, Penang, Malaysia, has been the most widely adopted (Ponzoni et al. 2008). Dey et al. (2000a, b, c) showed that production costs were lower with GIFT strains than non-GIFT strains and benefited both producers and consumers. Development of intensive raceway/tank production in Central and South America led to further growth of large-scale tilapia production (Engle 1997).

The availability of supply of high-quality fillets and marketing expertise has resulted in the successful introduction of fresh and frozen tilapia fillets into the U.S. and European markets. The development of export markets has resulted in a change in the major tilapia production centers and a shift from a dominance of tilapia from capture fisheries to tilapia produced on farms.

The U.S. is the major export market for tilapia. Imports of tilapia into the U.S. have grown rapidly, particularly since 2000. The majority of this growth has been in the form of imported fresh and frozen fillets. Tilapia are also imported as frozen whole fish, but these volumes have not increased as rapidly as the imported volumes of fresh and frozen tilapia fillets.

The major suppliers of fresh tilapia fillets to the U.S. in 2003 were Costa Rica, Ecuador, and Honduras. Tilapia from Costa Rica and Honduras originate primarily from farms designed to specialize in tilapia production while, in Ecuador, shrimp farmers have begun to diversify into tilapia production. The pond and processing infrastructure in Ecuador allowed shrimp farmers to move quickly into tilapia production as shrimp disease problems escalated.

Indonesia has been the major supplier of frozen tilapia fillets into the U.S. for many years. In more recent years, though, Taiwan has begun to increase exports of frozen fillets in addition to export of lower-priced, frozen whole tilapia. Taiwan continues to be the major supplier to the U.S. of frozen whole tilapia. The U.S. tilapia production industry has targeted sales of live tilapia to Asian and Hispanic grocery stores. Large cities such as New York, Toronto, Chicago, and San Francisco have historically been the major targets for the U.S. industry, but other markets have been developed successfully in smaller cities throughout the U.S.

Tilapia continue to be raised for subsistence purposes. In subsistence farming areas, tilapia are consumed whole, gutted, scaled, and either fried or roasted. Tilapia is now accepted in many national dishes around the world and is popular in many forms, including smoked, as sashimi, and even as fried tilapia skins. Whole dressed tilapia are common in many open-air markets around the world. Export markets, however, require primarily filleted products although there is also international trade in frozen whole tilapia. Frozen whole tilapia imported into the U.S. are targeted towards Asian grocery stores throughout the U.S. Taiwan has dominated the supply of frozen whole tilapia to the U.S. for many years but China increased the export volume of frozen whole tilapia to the U.S. in the early 2000s.

Large commercial tilapia ventures began to emerge in the 1990s. These businesses developed techniques that led to the production of export-quality fresh and frozen tilapia fillets.

Tilapia have been introduced from their native ranges in Africa and spread widely across the world (FAO 1997). The early introductions of tilapia (1950s to 1970s) were part of development projects targeted towards increasing the availability of animal protein in subsistence farming areas. Surplus tilapia were sold as a means of generating cash income.

While the growth of the global market for tilapia has been an undisputed success story in aquaculture, challenges are emerging that may begin to threaten the high rate of growth of tilapia sales. First, controversy emerged in the late 1990s over the use of carbon monoxide by some tilapia processing plants (*SeaFood Business* 2001–2003). Carbon monoxide treatment results in a deep red color to the fillets that is considered desirable. Second, tilapia fillets have a lower dress out ratio (fillet weight: live weight of fish) than do fillets of other fish species. This results in a higher relative meat cost at the processing plant for the same farm-gate price of fish that dress out at higher ratios. Third, tilapia growers have recently come under criticism by buyers of organic supermarkets in the U.S. for use of the hormone methyltestosterone to sex reverse young tilapia. Sex reversal has allowed tilapia growers to achieve higher yields and growth rates by stocking the faster-growing all-male populations of tilapia.

A more significant challenge to tilapia production worldwide may come from environmentalist groups. Some commercial-scale tilapia ventures depend upon high flows of surface water for the discharge of waste products. Increased awareness of environmental effects of effluent discharges may result in additional regulations. Also, concern globally over the introduction of exotic species is growing rapidly. Tilapia have become established in natural waters in many countries with tropical climates and are increasingly being labeled as an invasive species.

The tilapia industry can likely adapt to these challenges as it has to others over time. Challenges such as these arise as an industry matures and attracts increasing attention. The success in market development that has led to the growth of the tilapia industry will provide incentives to continue to adapt to new challenges that arise.

Summary

Much of the increased total fishery production worldwide is from aquaculture. Aquaculture costs of production have declined as the cost of capture fisheries has increased. The result has been an increase in the proportion of fish and seafood supplies from aquaculture as compared to capture fisheries. The majority of aquaculture products in the world are produced in Asia. Kelp, oysters, and carps are the major aquaculture species produced and sold. Japan and the U.S. are the major seafood markets worldwide, while the leading seafood exporter is Thailand. Aquaculture products, as compared to wild-caught fisheries products, offer advantages such as: (1) greater control over the product and its consistency; (2) freshness; (3) traceability; and (4) enhanced food safety. Nevertheless, some activist groups consider farmed product undesirable and unsustainable, while others prefer farm-raised product for its positive attributes.

Study and discussion questions

1 What percentage of the total world supply of fish and seafood was from aquaculture in 2012?
2 From a marketing perspective, how do aquaculture products differ from wild-caught products?
3 What are some of the reasons that aquaculture has grown so rapidly in recent years?
4 What are the most important farmed and wild-caught species worldwide? List and describe the five most important farmed and the five most important wild-caught species worldwide.
5 Describe the major aquaculture producing countries in terms of volumes, types of products produced, and target markets.
6 Describe the major world markets for seafood and aquaculture.
7 Discuss the controversies related to aquaculture and the various points of view.
8 How does consumption of seafood compare with that of other protein products in the U.S.?
9 Describe some important consumption trends related to seafood and aquaculture products.
10 How has the market for tilapia changed from the 1970s to recent times? (Remember that the term "market" includes both demand and supply considerations.)

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